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Method for power and time optimization of the travel mode in a vehicle/train,

Description

The invention relates to a method for power optimization of the travel mode in a vehicle/train having an overall route subdivided into a number of sections, according to the preamble of claim 1.

When schedules for rail traffic are drawn up, time reserves for unforeseen events and adverse operating conditions are included in the plans. Since during real journeys the operating conditions are typically more favorable than assumed in the planning, the time reserves which arise become available for other purposes. A particularly practical use of the time reserves is the saving of power by means of a suitable travel mode of the vehicle/train.

DD 208 324 A discloses a method for determining power-optimal travel regimes for rail-bound vehicles. On the basis of algorithmic and device capabilities from microengineering, within the context of simulation and optimization calculations, functional relationships are determined between the optimum changeover points of the individual travel regime phases and the travel time. In order to implement a technically and economically effective form of the power-saving train control, optimum travel strategies are synthesized for each travel time predefinition to be assigned to a current scheduling system. Here, functional relationships between the shut-down time, the shut-down travel and the brake initiation point are considered as a function of the travel time predefinition and are linearized piece by piece, with reference points being

predefined. The functional relationships for the switching points of the shut-down speed, the shut-down travel and the brake initiation point are determined in advance on a stationary EDP system on the basis of discrete travel times, by digital simulation of train journeys corresponding to the real route relationships and the real train and vehicle conditions. The on-board electronics installed on the vehicle primarily have the task of storing the reference points and processing the required computing rules.

In this connection, DE 3026652 A, DD 255 132 A and EP 0467377 B disclose methods relating to how a vehicle is moved in a power-optimal manner between two stops. In the case of long routes, a subdivision into a number of sections is proposed, an optimum partial solution being determined in each section, and the overall solution resulting from the combination of the partial solutions. The proposed methods for power optimization in each case take into consideration the overall route between two stops. However, no management of time reserves is carried out.

The uncertainty in the operating sequence, because the time reserves are provided in the schedule, is a maximum at the starting stop (starting station) and decreases continuously with increasing proximity to the destination stop (destination station). The operation of taking the decrease in uncertainty into account is traditionally carried out in route schedules in the form of times of passage for selected points on the route. At the same time, the time reserve is distributed uniformly over the overall route.

Further advantages of the proposed method emerge from the following description.

The invention will be explained in more detail below using the exemplary embodiment illustrated in the single drawing.

The figure shows the distance/time diagram of a vehicle, the overall route being divided into a number of individual sections and i constituting the index for the individual sections. n refers to the expedient number of sections for a prior calculation. The respective latest times of passage are identified by triangles. In addition, a time window is indicated by way of example. The time window is used to determine at which earliest and latest time of passage a specific section is to be passed by the vehicle.

According to the invention, time reserves are included in the power optimization in a flexible manner. Time reserves are provided in order to be able to react to unforeseen events and in order therefore to increase the robustness of the traffic sequence. Typically, a time allowance of, for example, 5% is granted. This time allowance is, for example, distributed uniformly over the overall route, it being possible for times of passage to be determined at any desired points on the route. According to the invention, the time reserves are included in a flexible manner in such a way that the time reserves which are not used in a route section are added proportionally to the following route sections, and in such a way that the time reserves granted to the individual route sections are assessed differently.

According to the invention, two possible procedures for including time reserves in the optimization in a flexible manner are provided:

According to a first possible procedure, the use of time reserve in a route section is taken into account as a "penalty term" in the optimization. The "penalty term" taken into account is, in particular, a monotonically falling function of time. In this way, the use of time reserve is "penalized" less, the further in the future, that is to say closer to the destination stop, it takes place.

According to a second possible procedure, the times of passage are included in the optimization problem as boundary conditions in such a way that on the one hand the required robustness is ensured, but on the other hand the solution which is optimal for saving power is adversely affected as little as possible. In order to satisfy the required robustness, it is sufficient for latest times of passage to be required. These latest times of passage are plotted in the figure as triangles, as already mentioned.

Further time restrictions can result, for example, from the simultaneous use of a route or of a route section by more than one vehicle. A higher-order operating control station can therefore place short-term predefinitions for times of passage in the form of time windows on the vehicle. A time window of this type is plotted by way of example in the figure, as already mentioned.

The invention provides for short-term predefinitions to be combined with long-term, known plans and to be included as boundary conditions in the power optimization by means of an optimization algorithm. Time windows resulting from this are included in the optimization as an earliest and a latest time of passage.

Optimization algorithms which are suitable for the proposed method are known, for example, from

Papageorgiou: Optimierung [Optimization], Chapters 10, 19 and in particular 20, Oldenbourg Verlag, 1996.